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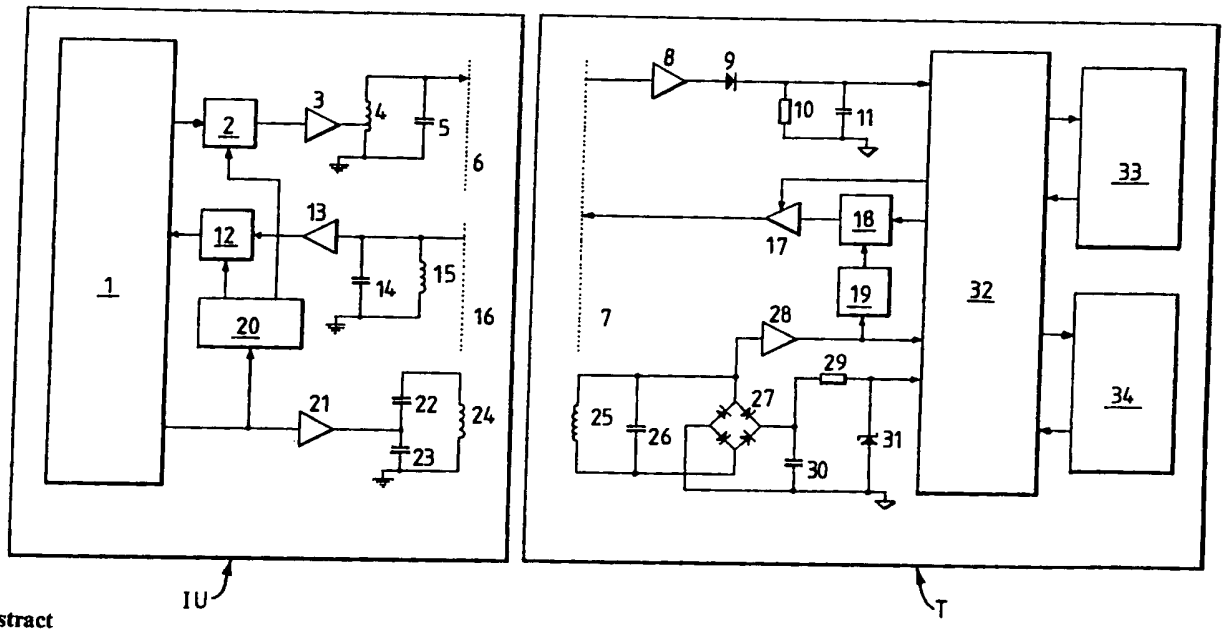
(54) Title: PROGRAMMABLE TRANSPONDER



(57) Abstract

A control system comprises an interrogation unit (IU) and at least one transponder (T) and includes means for transmitting data from the interrogation unit to the transponder in order to transfer a new applications program or new applications program routine into the program memory (33) of a microprocessor (32) of the transponder. The function of the transponder does not therefore have to be predetermined during its manufacture, but can be selected or altered subsequently. An electrostatic coupling arrangement is preferably provided for the transfer of data at least in one direction between the interrogation unit and the transponder.

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PROGRAMMABLE TRANSPONDER

This invention relates to a control system comprising an interrogation unit and at least one transponder. The control system may perform any of a wide variety of functions.

Recent developments in semiconductor electronic device technology make it now possible to provide computing and memory devices embedded in thin card-like packages with electrical communication between the card and an external system of which the "card" is a transportable active part.

Such devices will become increasingly important in many aspects of industrial, entertainment, financial and security markets, and are variously known as smartcards, IC cards, memory cards, tags or transponders. There are two categories of these devices, (1) those with electrical contacts to supply power to the card and transmit electrical signals between the card and the external system, and (2) those without electrical contacts, where the operating power for the card is usually derived from a local magnetic or electric field and signals are transmitted by the same or another field. Furthermore the "card" is dedicated to one particular application at its point of manufacture.

In accordance with this invention, there is provided a control system comprising an interrogation unit and at least one transponder and including means for transmitting data between the interrogation unit and transponder, the transponder including a microprocessor and a program memory for the microprocessor, and the interrogation unit being arranged to transmit data for transferring a new applications program or applications program routine into the program memory of the transponder.

Also in accordance with this invention, there is provided a transponder including a microprocessor, a program memory for the microprocessor, and means arranged to receive

data and respond to the received data to transfer a new applications program or applications program routine into the program memory of the transponder.

A complete program may be transferred from the interrogation unit into the program memory of the transponder, or one or more program routines may be transferred. The transferred program may replace or supplement one or more programs already stored in the program memory. Alternatively the transmitted data may serve to select or activate different programs (or routines) already stored in the program memory but not until then available to the microprocessor of the transponder.

Thus, in accordance with this invention the transponder may be constructed without its use necessarily being dedicated at the point of manufacture and whose singular or various uses can be defined, selected or changed after manufacture. The preferred embodiment of transponder has no external electrical contacts and retains all relevant data automatically on removal from its source of power, namely the interrogation unit.

In the preferred embodiment, the transponder is encapsulated in an electrically non-conducting material, in which case direct electrical connection for power or signals is not practicable. This embodiment instead uses inductive coupling to supply electrical power and a clock signal to the transponder circuitry and electrostatic coupling to transmit data in both directions between the interrogation unit and the transponder. However, in a modification inductive coupling may be used to transmit data in one direction (e.g. interrogation unit to transponder) and electrostatic coupling to transmit data in the other direction (e.g. transponder to interrogation unit). Electrostatic or capacitive coupling has the advantages of eliminating the tuned coupling circuits and enabling much faster data transfer.

An embodiment of this invention will now be

described by way of examples only and with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic diagam of an interrogation unit and a transponder in accordance with the invention; and

FIGURE 2 is a plan view of the electrode arrangement of the interrogation unit and transponder.

Referring to Figure 1, there is shown an interrogation unit IU and a transponder T. Electrical power to the transponder is supplied through inductive coupling between a tuned circuit in the interrogation unit composed of capacitors 22, 23 and inductance 24 and a corresponding tuned circuit in the transponder, composed of inductance 25 and capacitor 26. Both tuned circuits are arranged to resonate at the frequency fc of the power carrier signal supplied from the control unit 1 through a buffer 21. A bridge rectifier 27 and smoothing capacitor 30 in the transponder provide the dc supply voltage which is regulated by a circuit comprising a resistor 29 and a Zener diode 31.

A clock signal at a frequency fc for the transponder microprocessor 32 is also provided from the tuned circuit 25 and 26 through a buffer 28. In other forms of the invention the clock signal may be derived by division of the power carrier frequency fc.

Digital data from the control unit 1 is 100% amplitude modulated 2 onto a carrier of frequency ft so that logic '0', logic '1' or the end of a transmission sequence is indicated by the length of the carrier burst. By this means a word of arbitary wordlength can be transmitted to the transponder. It is convenient to derive the carrier ft from the power and clock frequency fc by a divider 20 as shown in Figure 1 so that ft is an integral multiple of fc, but other frequencies are equally suitable.

The amplitude modulated data is buffered by an amplifier 3 which drives a step-up tuned circuit comprising

inductance 4 and capacitor 5 and resonant at the carrier frequeency ft to provide a high voltage drive to a transmitter electrode 6. In the preferred form of the invention this electrode is a grid of parallel conducting strips positioned inside and co-planar with the power drive coil 24 to reduce eddy current losses as shown in Figure 2. Other configurations which provide electrostatic coupling to the transponder and minimise eddy current losses such as a conducting spiral or a sheet of high resistance material are also possible.

An electrode 7 in the transponder is electrostatically coupled to the transmitter electrode 6 to receive the amplitude modulated data. In the preferred form of the invention electrode 7 is arranged as a parallel grid of conductors positioned inside and co-planar with the power carrier inductor 25 to reduce eddy current losses but may also be in the form of a conducting zig-zag or spiral pattern, or a sheet of high resistance material. The received signal is buffered by an amplifier 8 and demodulated by the peak detector consisting of a series diode 9 and a low pass filter comprising shunt resistor 10 and capacitor 11. The resultant envelope signal is passed to the transponder microprocessor 32. Appropriate software routines executed by the microprocessor 32 then retrieve the original digital data sequence.

Digital data from the transponder microprocessor 32 is phase modulated onto a carrier of frequency fr in a modulator 18. In the preferrred form of the invention fr is an even integral submultiple of the power and clock frequency fc derived by a divider 19 as shown in Figure 1, but other frequencies are possible. The phase modulated data drives the common transmitting and receiving electrode 7 through a tristate buffer 17. When the transponder T is receiving data the output stage of this buffer 17 is inactive, that is to say at high impedance, to minimise loading of the received signal. It becomes active when the transponder T is transmitting data.

The phase modulated data is received at the

interrogation unit IU by an electrode 16 which is electrostatically coupled to the transponder electrode 7. In the preferred form of the invention, the electrode 16 is a parallel grid of conducting strips interleaved with, but electrically separate from, the transmitting electrode 6 as shown in Figure 2. Such electrical separation reduces breakthrough of the high voltage transmitting signal to the receiver circuits. In other forms of the invention the electrode may be located distant from the transmitting electrode 6. In yet other forms the transmitting electrode 6 may itself serve as the receiving electrode.

A tuned circuit comprising capacitor 14 and inductance 15 receives the signal from receiver electrode 6 and provides some rejection of noise and spurious signals present in the received signal. After passing through a bandpass amplifier 13, which provides gain and further rejection of noise and spurious signals, the phase modulated data is demodulated in a phase sensitive detector 12 using a reference signal fp derived by division of the power and clock signal fc in divider 20. The division ratio is the same as the division ratio in the transponder T and so the reference signal will have the same frequency as the carrier fr and will be phase locked to it.

Although data transfer between interrrogation unit and a transponder can be achieved with an electrically isolated transponder as shown in Figure 1, the transfer in both directions is enhanced and hence the maximum range increased if a common connection between the interrogation unit and a transponder is present. Since the data transfer is through electrostatic coupling this common connection may be of high impedance, and connection through the body of a user and ground is adequate.

The required electrical path to the circuitry within the transponder may be made with a conducting grid on the back surface of the encapsulation suitably arranged to minimise eddy current losses, with a high resistance coating or by

loading part of the encapsulation material with a conducting material such as carbon.

Instead of using electrostatic or capacitive coupling for data transfer in both directions, inductive coupling may be used for data transfer in one direction and electostatic coupling for data transfer in the opposite direction.

The function performed by the transponder microprocessor 32 and hence the operations on data transmitted to the transponder is determined by the active program stored within the transponder and the algorithm contained within that program. In this invention the program is stored partly in non-volatile or permanent memory 33 and partly in volatile memory 34 whose contents can be altered under control of the program stored in the non-volatile portion 33 of the memory. Several different programs of program segments may be simultaneously contained in volatile or non-volatile memory. The alterable memory 34 is preferably EEPROM, that is Electrically Eraseable and Programmable Read Only Memory, but battery-backed Random Access Memory (RAM) is equally suitable. The non-volatile memory 33 may be masked Read Only Memory (ROM). Each part 33, 34 of the memory may be provided either as an external component interfaced to the transponder microprocessor as shown in Figure 1, as an integral part of the microprocessor, or as a unique custom VLSI chip.

A program suitable for controlling the reception and transmission of data by the transponder is written into the non-volatile memory 33 in the transponder at the time of manufacture. The fixed program also contains appropriate software routines for initially storing and subsequently altering the program stored in the volatile portion 34 of the transponder memory.

Data received by the transponder is of three kinds:- first, it may be data which the transponder is required to process in a way determined by a specific algorithm and/or a

specific code contained within the transponder to produce replies which enable the interrrogation unit uniquely to identify that individual transponder.

Second, the data may be processed and returned to the interrogation unit by the transponder whose instantaneous operation is defined by the currently active stored program.

Finally, the data may be written either directly or after descrambling or decryption into the volatile memory 34 to define a new program or algorithm. By this means the function and/or the identify of the transponder may be initially defined or subsequently altered to suit a particular application. Data intended to alter the function of the transponder in this way must be positively identified to avoid the danger of unintentional reprogramming but to allow intentional program changes as part of the normal operation of the transponder. In the preferred form of the invention reprogramming data is distinguished from normal data by using a unique wordlength of 32 bits whereas normal data is allowed to have a wordlength of not more than 16 bits. In addition, error detecting and correcting words are included in the sequence of 32 bit reprogramming words to reduce the possibility of unintentional reprogramming to a very low value. In another form of the invention reprogramming data is distinguished by a special sequence of normal length data words which identify a block of subsequent data words as reprogramming data.

CLAIMS

1) A control system comprising an interrogation unit and at least one transponder and including means for transmitting data between the interrogation unit and the transponder, the transponder including a microprocessor and a program memory for the microprocessor, and the interrogation unit being arranged to transmit data for transferring a new applications program or applications program routine into the program memory of the transponder.

2) A control system as claimed in claim 1, arranged to transfer the new applications program or routine from the interrogation unit to the transponder.

3) A control system as claimed in claim 1, in which the new applications program or routine is pre-stored in the program memory and the interrogation unit is arranged to transmit data to render that program or routine active.

4) A control system as claimed in claim 1, comprising electrostatic coupling means for the transfer of data at least in one direction between the interrogation unit and the transponder.

5) A control system as claimed in claim 4, comprising inductive coupling means for the transfer of data in the opposite direction between interrogation unit and transponder.

6) A transponder including a microprocessor, a program memory for the microprocessor, and means arranged to receive data from an interrogation unit and respond to the received data to transfer a new applications program or applications program routine into the program memory of the transponder.

7) A transponder as claimed in claim 6, arranged to receive the new program or routine from the interrogation unit.

8) A transponder as claimed in claim 6, in which the new applications program or routine is pre-stored in the program memory and the transponder responds to the data received from the interrogation unit to render that program or routine active.

9) A transponder as claimed in claim 6, comprising electrostatic coupling means for the transfer of data at least in one direction between the interrogation unit and transponder.

10) A transponder as claimed in claim 9, comprising inductive coupling means for the transfer of data in the opposite direction between the interrogation unit and transponder.

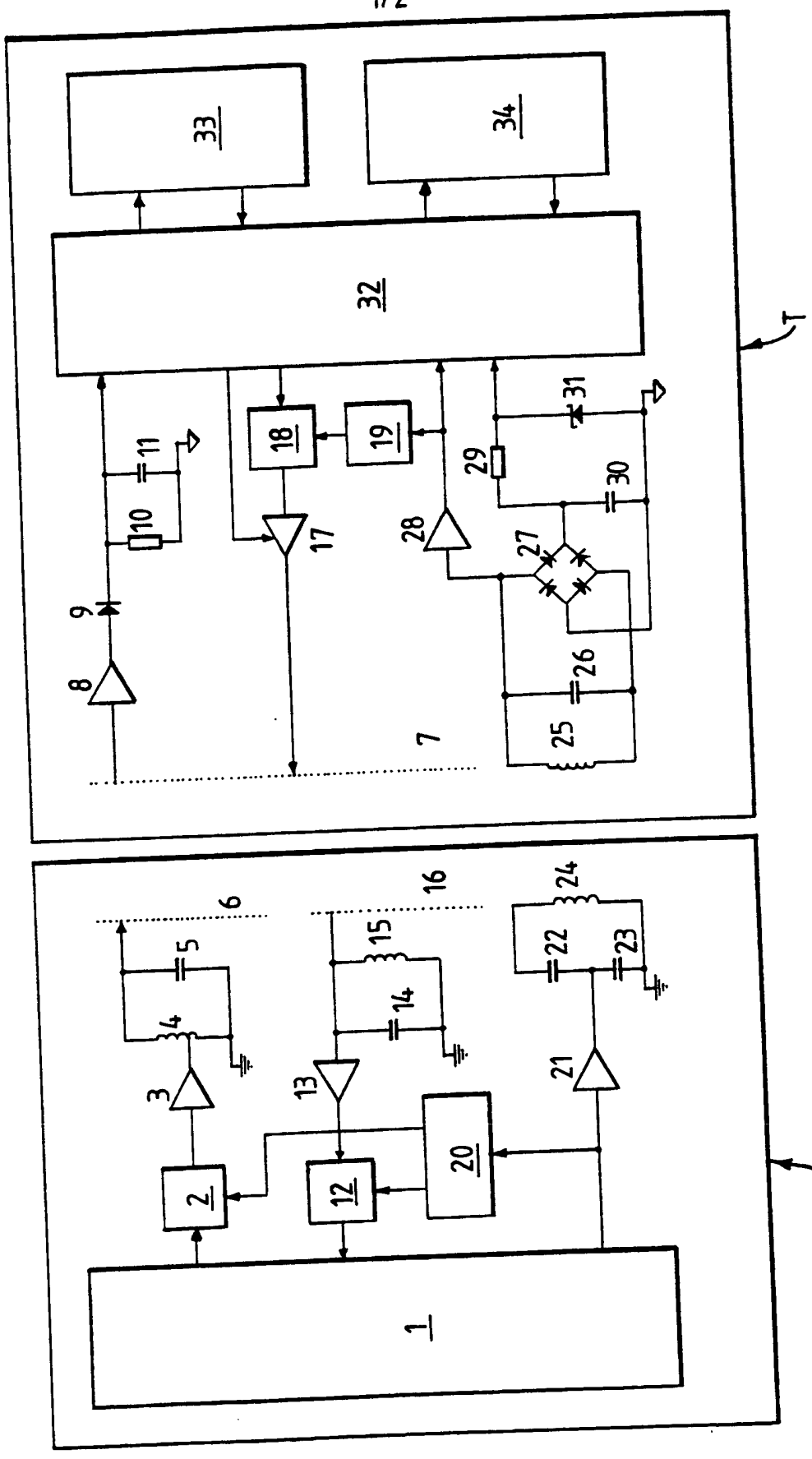


Fig.1.

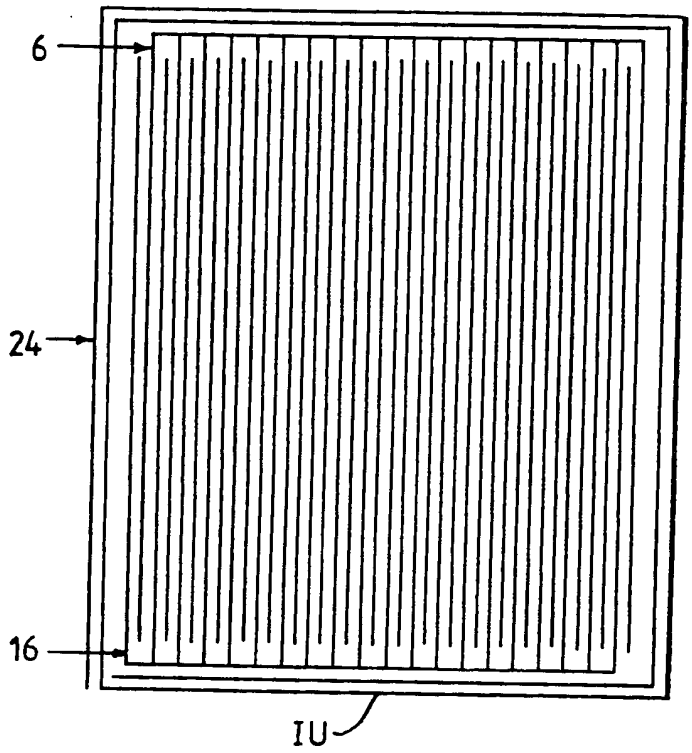
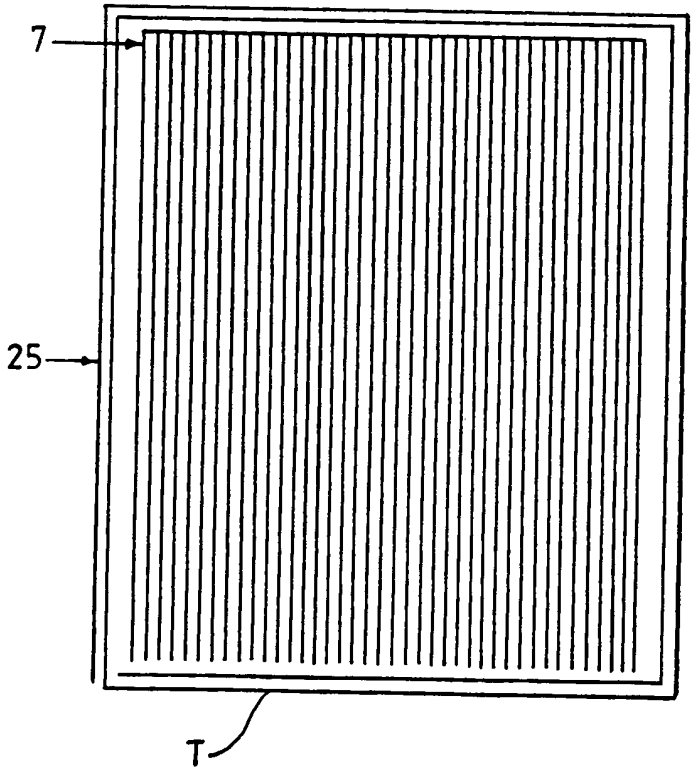


Fig. 2.



INTERNATIONAL SEARCH REPORT

PCT/GB 89/01391

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G06K1/12 ; G06K7/00 ; G06K7/08

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G06K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category [a]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	EP,A,57602 (CHALMERS D.A.) 11 August 1982 see the whole document ---	1-3, 6-8
X	WO,A,8604171 (INDALA CORP.) 17 July 1986 see page 15, line 1 - page 16, line 15; claims 1-5, 20-25; figure 7 ---	1-2, 4-7, 9-10

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
26 FEBRUARY 1990	22.03.90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	GYSEN L.A.D.

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

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SA 32672

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 26/02/90

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-57602	11-08-82	GB-A,B 2092353	11-08-82
		AU-B- 559431	12-03-87
		AU-A- 8623282	26-01-84
		CA-A- 1191271	30-07-85
WO-A-8604171	17-07-86	US-A- 4818855	04-04-89
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		CA-A- 1253591	02-05-89
		EP-A- 0209588	28-01-87
		JP-T- 62501671	02-07-87

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

CORRECTED VERSION *

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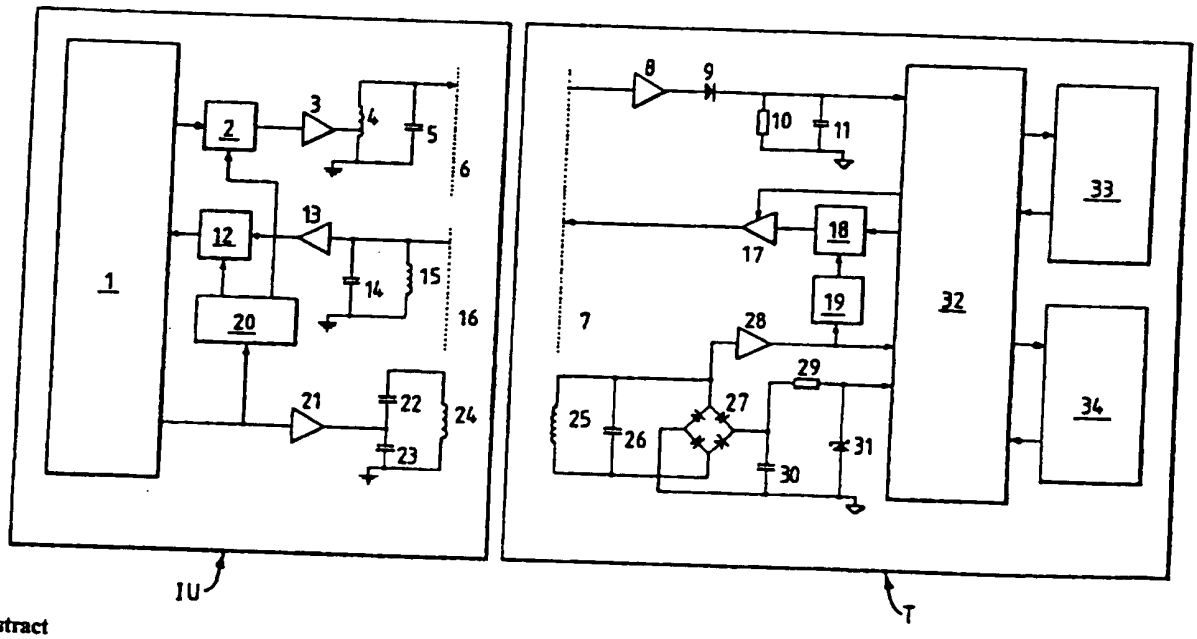

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